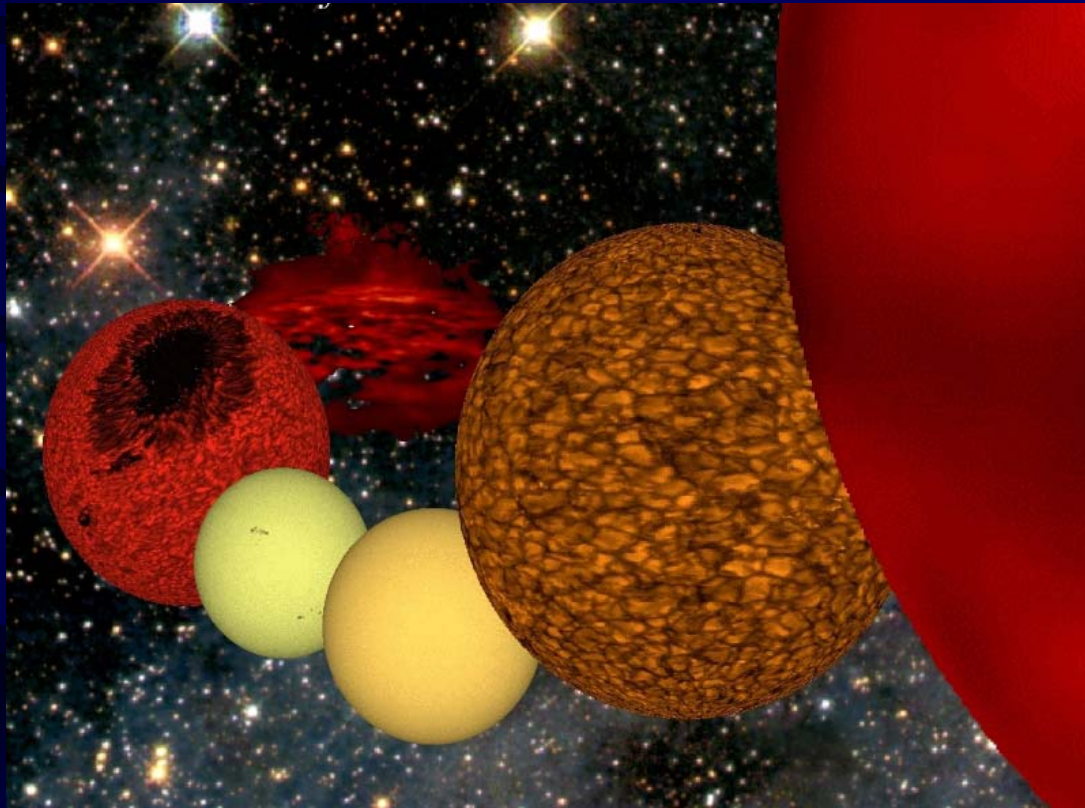


# The Stellar Imager (SI) Mission Concept

Imaging the Surfaces of Distant Stars



K. G. Carpenter (NASA/GSFC) , C. J. Schrijver (LMMS)  
and the SI Mission Concept Development Team

*Executive Summary: 23 July 2004*

# Mission Concept Development Team

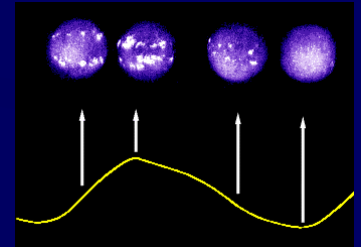
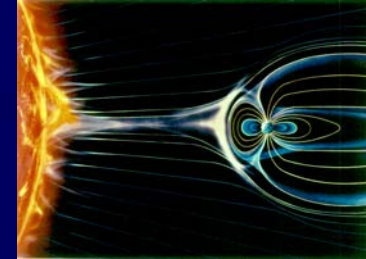
- NASA/GSFC leads large Vision Mission Concept Development Team
  - **NASA-GSFC:** K. Carpenter (Study Lead), C. Bowers, W. Danchi, J. Leitner, A. Liu, R. Lyon , L. Mazzuca, R. Moe
  - **LMMS/ATC:** Carolus Schrijver (Science Lead), D. Chenette
  - **BATC:** S. Kilston, C. Noecker, R. Linfield, M. Lieber, D. Miller
  - **NGST:** R. Polidan, B. Kirkham
  - **JPL:** N. Murphy, M. Shao, F. Hadaegh, J. Breckinridge, G. Blackwood
  - **NRL/NPOI:** T. Armstrong, X. Zhang
  - **Seabrook Eng:** D. Mozurkewich
  - **Sigma Space:** J. Marzouk
  - **STScI:** R. Allen
  - **UMD:** L. Mundy
  - **SAO:** M. Karovska, J. Phillips, P. Nisenson, S. Baliunas, S. Korzennik, W. Soon
  - **SUNY:** F. Walter
  - **CU:** A. Brown, G. Harper
  - **Potsdam U.:** Klaus Strassmeier
  - **U Aarhus:** Jörgen Christensen-Dalsgaard
  - **Kiepenheuer Inst:** Oscar Van der Lühe

# Primary Science Goals

- Study spatial and temporal stellar **magnetic** activity patterns in a sample of stars covering a broad range of activity level
  - Enable improved forecasting of solar activity on time scales of days to centuries
  - Understand the impact of stellar magnetic activity on planetary climates and astrobiology
- Measure internal stellar structure and rotation
- Complete the assessment of external solar systems
  - image the central stars and determine the impact of the activity of those stars on the habitability of the surrounding planets

# Value to Society: Space-Weather & Earth-Climate Forecasting

- SI's observational capabilities are essential to the development and validation of a model of the solar/stellar dynamo, which is needed to
  - understand past solar activity
  - enable forecasting of solar and heliospheric activity days to decades in advance
  - anticipate the impact of those changes on the earth's biosphere and society from
    - long-term changes which effect climate, such as Maunder minima/grand maxima, which lead to lower/higher overall global temperatures and can cause crop failures, etc.
    - short-term changes, e.g. enhanced activity/flares, which have the potential to
      - disable communication satellites
      - knock out power grids
      - increase the speed of corrosion of oil pipelines
      - place astronauts at risk from particle radiation





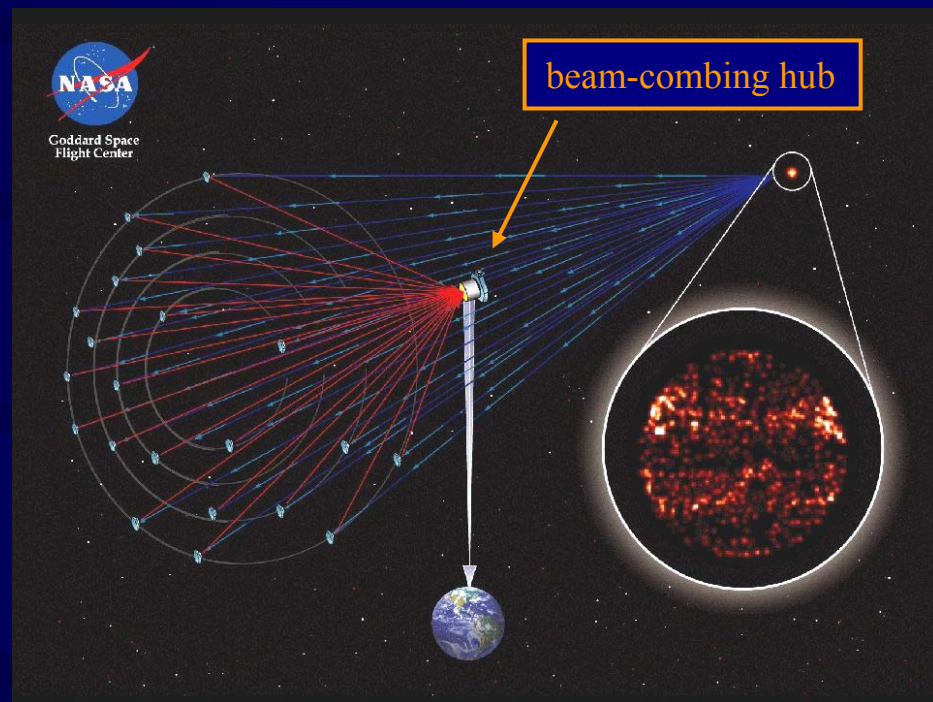
# “Strawman” Full-SI Mission Concept

- space-based UV-optical Fizeau Interferometer
  - located near the sun-earth L2 point to enable precision formation flying
  - > 20 primary mirrors distributed over virtual spherical surface 0.5 km in diameter

## Capabilities Provided

- an angular resolution of **60 & 120 micro-arcsec** at 1550 & 2800 Å
- ~ 1000 pixels of resolution over the surface of nearby dwarf stars
- observations in
  - ~10-Ångstrom UV pass bands
    - C IV (100,000 K)
    - Mg II h&k (10,000 K)
  - broadband, near-UV or optical continuum (3,000-10,000 K)
- a long-term (> 10 year) mission to study stellar activity cycles:
  - individual telescopes/central hub can be refurbished or replaced

hub and primary mirrors formation fly with ~ cm precision, mirror actuators maintain optical path lengths to within 5 nm



approximate distance to hub from center of array is 65 km

# Place in NASA/ESA Strategic Roadmaps

- *SI* is on strategic path of NASA Origins interferometry missions
  - it is a stepping stone towards crucial technology...
    - *SI* is comparable in complexity to the *Terrestrial Planet Finder*, and it may serve as a useful technological and operational pathfinder for *Planet Imager*
  - ... while addressing science goals of 3 NASA/OSS research Themes
    - understand why the sun varies (SEC)
    - understand the origin of stars, planetary systems, and life (Origins)
    - understand the structure and evolution of stars (SEU)
  - it is complementary to the planetary imaging interferometers
    - *Terrestrial Planet Finder/Darwin*, and *Planet Imager* null the stellar light to find and image planets
    - *Stellar Imager* images the central star to study the effects of that star on the habitability of planets and the formation of life on them.

*TPF/Darwin, SI, and PI* together provide complete views of other solar systems



# SI and General Astrophysics

**A long-baseline interferometer in space  
benefits many fields of astrophysics**



## **Active Galactic Nuclei**

transition zone between BLR & NLR,  
origin/orientation of jets

## **Quasi-stellar Objects & Black Holes**

close-in structure,  
radiation from accretion processes

## **Supernovae**

close-in spatial structure

## **Stellar interiors**

internal structure in stars outside  
solar parameters

## **Hot Stars**

hot polar winds, non-radial pulsations,  
envelopes and shells of Be-stars

## **Spectroscopic binary stars**

observe companions & orbits,  
determine stellar properties,  
perform key tests of stellar evolution

## **Interacting Binary Stars**

resolve mass-exchange, dynamical  
evolution/accretion,  
study more efficient dynamos

## **Forming Stars/Disk systems:** accretion

foot-points & magnetic field structure

## **Cool, Evolved Giant & Supergiant Stars, and**

## **Long-Period/Semi-Regular Variables**

spatiotemporal structure of extended  
atmospheres/winds, shocks



# Current Status of SI

- SI included in far-horizon NASA SEC Roadmap
- SI selected for further concept development by the NASA HQ 2003 Vision Mission NRA review
- Major Partnerships established with LMATC, BATC, JPL, SAO, UCO to carry out further concept/technology development
- Phase I (7 primary elements) of the Fizeau Interferometry Testbed (FIT) has begun operation to develop closed-loop optical control of a multi-element array
- Next Steps
  - Continue Architecture Trade/Feasibility Studies
  - Test/demonstrate design concepts with ground-based testbed (the FIT)
  - Gather & utilize additional community input
  - Produce book summarizing science/societal motivations for mission, technology roadmap, and most promising architecture options

For more information, see: <http://hires.gsfc.nasa.gov/~si>